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ABSTRACT

Several verbal and nonverbal tests and measures, including the General Classification Test (GCT), Mechanical Test (MECH), Arithmetic Test (ARI), Clerical Test (CLER), Raven Progressive Matrices (RPM), age, education level, race, speaking English as a native or second language, modification of hand use, and measures of handedness and eyedness were used to differentiate between a group of recruits enrolled in a Navy remedial reading program and a non-remedial comparison recruit group. These tests and measures were also associated with reading achievement attained by the remedial recruits as measured by pre- and post-test performance on the comprehension subtest of the Gates-MacGinitie Reading Test. The results show that verbal tests (GCT, MECH, and ARI) were correlated highly with the group (remedial/non-remedial) criterion. The data indicate that the RPM, which was associated significantly with the group criteria, was also highly related to these other verbal measures. The CLER test, however, was found to have only a low order correlation with these other verbal tests. CLER scores were found to be correlated significantly with the group criterion. Other nonverbal measures, including education, race, modification of hand use, and consistency of hand and eye use, were also shown to differentiate significantly between the two groups. (Author/MV)

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CNETS REPORT 1-76

MEASUREMENT OF READING PROFICIENCY AMONG NAVY RECRUITS

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THE CHIEF OF NAVAL EDUCATION AND TRAINING SUPPORT

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1. CNET SUPPORT Report 1-76, "Measurement of Reading Proficiency Among Navy Recruits," is promulgated for information in the interest of developing more productive programs in remedial reading for basic skills training in the Navy.

2. The conclusions and recommendations contained in Report 1-76 are those of the researcher and are not necessarily those of the CNET SUPPORT.

3. This publication has been reviewed under the provisions of SECNAVINST 5600.16 and is approved.

Wayne Hughes

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1.0 SUMMARY. Several verbal and nonverbal tests and measures, including the General Classification Test (GCT), Mechanical Test (MECH), Arithmetic Test (ARI), Clerical Test (CLER), Raven Progressive Matrices (RPM), age, education level, race, speaking English as a native or second language, modification of hand use, and measures of handedness and eyedness were used to differentiate between a group of recruits enrolled in a Navy remedial reading program (RR group) and a non-remedial comparison recruit group (C group). These tests and measures were also associated with reading achievement attained by the remedial recruits as measured by pre- and post-test performance on the comprehension subtest of the Gates-MacGinitie Reading Test. The results show that verbal tests (GCT, MECH, and ARI) were correlated highly with the group (remedial/non-remedial) criterion. The data indicate that the RPM, which was associated significantly with the group criteria, was also highly related to these other verbal measures, although previous research has assumed that the RPM is a test of nonverbal spatial skills. The CLER test, however, was found to have only a low order correlation with these other verbal tests, indicating that the CLER test may be more a measure of nonverbal than of verbal skills. CLER scores were found to be correlated significantly with the group criterion. Other nonverbal measures, including education, race, modification of hand use, and consistency of hand and eye use, were also shown to

differentiate significantly between the two groups. Multiple regression analysis demonstrated that the GCT, RPM, and race subsumed the criterion variance accounted for by the other significant measures, with those recruits who had lower GCT and RPM scores, and who were non-Caucasian, being more likely to be in the RR group. Achievement within the remedial reading program, however, was found to be positively and significantly related to race and to several specific types of handedness. Non-Caucasians, as well as those who used the left hand to perform peeling and drinking movements, were more likely to attain higher post-test reading comprehension scores and show larger improvements over pre-test reading comprehension scores than Caucasian recruits or recruits who used the right hand to perform these hand movements. These results show that conventional tests of verbal intelligence, especially the GCT, perceptual measures such as the RPM, and cultural or socioeconomic factors such as race, are useful in differentiating between poor and better readers. Determination of whether a recruit should be in the remedial or non-remedial group was easier, however, than determining reading comprehension achievement among members of the remedial reading group. Race and handedness were found to be among the most useful measures in determining reading achievement among members of the remedial reading group. The findings for handedness may be an indication of the facility with which word processing is accom-

plished by poor readers at the peripheral (sensory) and central (brain) levels, while the results for race may indicate that while non-Caucasian recruits are more likely than Caucasian recruits to require reading remediation, non-Caucasians perform better in the remedial reading program than Caucasian recruits. Non-Caucasian recruits may, therefore, have reading problems that are related to cultural factors such as inappropriate vocabulary development, while Caucasian recruits may have more basic and difficult reading problems such as poor word attack skills or impaired visual scanning patterns. If this interpretation is correct, then current remedial reading programs should be restructured to correct for these entrance level differences.

2.0 ACKNOWLEDGEMENTS. The assistance of LT James M. LaRocco of the Naval Health Research Center, San Diego, California in collecting and collating the data, and in reviewing the draft report, is most appreciated. The extensive statistical analyses and computer programming assistance provided by Mr. Robert Doucette and Miss Lucille Shirk of the Naval Education and Training Program Development Center was especially helpful, and the data presented in this report could not have been organized and interpreted without the dedication and resourcefulness with which they performed these tasks. The cooperation of the staff of the Recruit Training Command, San Diego, especially the instructors

associated with the Academic Remedial Training program, is most gratefully acknowledged.

3.0 PURPOSE. This report will present information about tests and measures which may be useful in identifying Navy personnel who may require remedial reading training, as well as information about the characteristics of those personnel who are most successful in current Navy remedial reading programs. This information should assist in the selection of personnel for basic reading skills training, as well as assist in the overall planning and management of these remediation programs.

4.0 BACKGROUND. Effective performance in the military, as well as many other occupational groups, is highly dependent on reading skills. Hoiberg, Hysham, & Berry (reference 1) have shown that successful completion of the first four-year enlistment period in the Navy is related significantly to reading skills, while Fisher (reference 2) found similar results for Air Force personnel. The need for adequate reading skill development in the Navy begins at the recruit level. The recruit must read information which will be necessary for successful career adjustment and advancement. This information includes legal rights, career opportunities and benefits, preventative health programs and medical care, the structure and operation of ships, and basic rules of conduct and safety. Comprehension of this information must be demonstrated before a recruit can graduate from basic

military training. Following graduation, reading will be necessary to qualify for, and complete, technical training. Aboard ship, reading is essential to operate and maintain complex equipment, as well as to prepare for the written examinations which are required to advance in rank. In addition, reading is often a major source of entertainment during lengthy deployments at sea.

In order to ensure that Navy personnel are prepared adequately to cope with these reading requirements, the Navy has recommended that the ninth grade level be adopted as the minimum reading standard to replace the traditional fifth grade level. In addition, remedial programs have been established to improve reading skills among recruits. Inasmuch as these remedial programs will probably be expanded to train recruits to the proposed ninth grade level, a more valid and efficient screening process than that which is currently used will have to be developed. At present, Navy recruits at Recruit Training Command, San Diego, are remediated only if (a) they fail the first written examination administered after two weeks of basic military training, and (b) they are found to read below the fifth grade level. The present screening technique may fail to identify adequately those recruits who may have poor reading skills but who have nonetheless managed to pass the initial written examination using other skills and aptitudes. This possibility is demonstrated amply in the above findings of Hoiberg et al.

(reference 1) which showed that thousands of recruits with poor reading skills similar to those who have attended remedial reading programs are being graduated from recruit training without benefit of remediation. In addition, Hoiberg et al. (reference 1) showed that the first enlistment (four-year) effectiveness of these poor readers (both remediated and non-remediated) was substantially below the Navy average. These findings indicate that (a) more recruits should be screened for remediation, and (b) more than a fifth grade reading level appears to be necessary for long-term (four-year) effectiveness.

Little research has been done to develop screening techniques for remedial reading programs, probably because most of these programs are not operated on the large scale required in military settings, and because most of these programs are conducted for children who have been referred directly by teachers from the classroom. Previous research (reference 3) has shown that if the ninth grade reading level is adopted as the Navy standard, over 25% of the recruits who enter the Navy will require some form of reading remediation. This figure represents an annual training input of over 25,000 recruits for the Navy alone. This same research has indicated that scores from the Navy Basic Test Battery (BTB), especially the verbal intelligence test (General Classification Test or GCT), correlate highly with comprehension scores on the Gates-MacGinitie Reading Test

among Navy recruits, and the GCT may, therefore, be useful in screening recruits for reading remediation programs. These findings are consistent with other research which has demonstrated high correlations between conventional tests of verbal intelligence and reading performance among both adults and children (references 4 and 5). Other data (references 6 and 7) indicate that caution should be exercised in using the GCT and other BTB scores as the only measures for identifying poor readers. These data show that recruits from non-norm cultures appear to have the intelligence, aptitudes and perhaps many of the reading skills necessary to perform effectively in formal training situations, although they may have scored significantly lower than the norm group on the BTB. Any remedial screening program, therefore, should include measures that have demonstrated less cultural bias than the BTB. A test that appears to satisfy this criterion is the Raven Progressive Matrices (RPM). Similar reliabilities, validities, norms, and factors have been found for the RPM among several different cultural groups (references 8, 9 and 10).

Other tests which may be useful in identifying poor readers involve measurement of handedness and eyedness (laterality). These tests also appear to be free of cultural bias. Harris (reference 11) presented evidence that ambilaterality (equal use of both hands and eyes) may be related to reading difficulties among children, while Palmer

(reference 12) has mentioned that lateral consistency (use of the same side -- eyes and hands -- across several tasks) may be used to measure the effectiveness of a variety of performances, including reading. Recent findings by Boos & Hillerich (reference 13), showed that although the same group of children exhibited more ambilaterity over a six-year period, neither ambilaterality nor crossed laterality (different laterality between the hands and eyes) was related to reading achievement attained over this period. Boos & Hellerich, however, tested only children who progressed normally in school over this six-year period. Children who failed to make normal progress may therefore have had reading problems associated with laterality. The data in reference 13 also did not determine if inconsistent laterality was associated with reading achievement.

The above measures may be useful in determining which of the recruits who are attending reading remediation programs may achieve the highest reading scores. The existing Navy remedial reading programs conform to conventional adult basic education courses found in many high schools and colleges throughout the United States, offering small group training in phonics, word attack skills, and vocabulary development over a six-week period. Little is known, however, about the characteristics of the trainees who are most successful in these programs. The following research, therefore, will not only analyze the characteristics of

those who should be screened for participation in remedial reading programs, but also the characteristics of those who achieve the highest reading levels under the present programs.

5.0 METHODS. The following sections describe the subjects, tests, procedures, and statistics used to collect and analyze the data.

5.1 Subjects. Subjects were 87 male recruits attending the third week of Navy basic training at the Recruit Training Command, San Diego, California. Thirty-four of these recruits (the RR group) were attending the first week of the remedial reading program, having been placed into the remediation program after two weeks of recruit training through the procedures previously described (failing the first written examination and obtaining a comprehension score below the fifth grade level on the Gates-MacGinitie Reading Test). The remaining 53 recruits were members of a single recruit company who were progressing normally through recruit training. These recruits were the comparison group (C group).

5.2 Testing Procedures. The two groups (RR and C) were tested three days apart, at the same hour each day. The tests described below were contained in a booklet with a separate answer sheet. The measures were group-administered. In order to avoid bias that could result from reading

problems, the written questions were read slowly to each group and repeated if necessary.

5.3 Independent Measures. As previously mentioned, a variety of intelligence, aptitude, demographic, perceptual, and laterality data were collected. The following paragraphs described these measures, as well as the administration and scoring procedures.

5.3.1 Verbal Intelligence and Aptitudes. The Navy Basic Test Battery (BTB) scores were obtained from official records. The BTB consists of the following measures:

General Classification Test (GCT)--a test of general, verbal ability which consists of verbal analogies and sentence completions.

Mechanical Test (MECH)--a largely pictorial measure which tests for understanding of everyday physical situations and mechanical relationships.

Arithmetic Test (ARI)--a written test consisting of word problems which require arithmetic reasoning to solve.

Clerical Test (CLER)--a largely nonverbal test of perceptual speed which consists of matching series of numbers.

BTB scores have been standardized on a large, unrestricted recruit sample consisting mostly of lower and middle class Caucasian males. The standard scores have a mean of 50 and a standard deviation of 10.

5.3.2 Nonverbal Intelligence and Perception. The Raven Progressive Matrices (RPM), which is assumed to be less biased than the BTB for English culture and verbal fluency (reference 9), was used as a measure of nonverbal intelli-

gence. The 40 incomplete RPM test patterns were contained in a booklet with a single, incomplete test pattern on the upper half of each page. The bottom half of the page contained five possible completion patterns, only one of which was correct. The members of each group (RR or C) were told to answer the RPM carefully and to take as much time as necessary to find the correct answer. The score was the total number of completion patterns chosen correctly.

5.3.3 Demographic Measures. Demographic data included age (in years), education level (in years), race (Caucasian and non-Caucasian), and whether English was a native or second language. The recruits were also asked if they had ever used the other hand for any writing or non-writing activities (this item is referred to as "Modified Hand Use").

5.3.4 Laterality Test: Handedness. A slightly modified version of the laterality test developed by Crovitz & Zener (reference 14) was used to test for handedness and eyedness (laterality). Most of the 14 handedness items developed by Crovitz & Zener were used in the present test with a few exceptions. The Crovitz & Zener item concerning which hand is used to hold a dish when wiping was modified to read "Which hand do you use to hold a shoe when polishing?" (a question which is more appropriate for this recruit sample). The Crovitz & Zener item asking which hand is used to hold a tennis racket was modified to include either a tennis racket or ping pong paddle. An additional item, not included in

the original 14 items of the Crovitz & Zener test, asked "Which hand do you use to hold a fork when eating?". The following 5-point scale, originally developed by Crovitz & Zener, was adopted for use in responding to the present 15-item handedness test:

1 = Right hand always
2 = Right hand more than half the time, but not always
3 = Both hands equally often (the right and left hands are each used about half the time)
4 = Left hand more than half the time, but not always
5 = Left hand always

5.3.5 Laterality Test: Eyedness. The present laterality test also consisted of the eyedness measure described by Crovitz & Zener. The eyedness measure was included as the sixteenth item in determining the total laterality score. The following instructions were read to the members of each recruit group (RR or C) prior to testing for eyedness:

> Please sit erect in your chair and look at the white circle drawn on the blackboard. While looking at this circle, put your pencil in your hand (specify right or left) and hold it vertically between your eyes, close to your nose--like this (demonstrate). Remember to keep both of your eyes open and looking at the circle while you are doing this. Now, with both eyes still open and looking at the circle, move your hand slowly outward, away from your nose, aiming the pencil toward the circle--like this (demonstrate). Remember to keep both eyes open and to aim the pencil toward the circle. With your arm outstretched and both eyes open, center the pencil on the circle--like this (demonstrate). Don't worry if you see two images of the pencil while you're trying to center on the circle with both eyes open. Choose one of these images for centering, and ignore the other image. After you have centered the pencil as best you can, close your eye (specify right or left). Notice whether the pencil is still in line with the circle or whether it moved to the right or to the left of the circle. If the pencil moved to the right of the circle, fill in answer number 1; if it moved to the left of the circle,

fill in answer number 2; if the pencil stayed in line with the circle and did not move, fill in answer number 3.

As with the Crovitz & Zener eyedness test, eight trials were administered. The following hand and eye combinations were tested over these eight eyedness trials:

Trial 1 -- Pencil held in the right hand, left eye closed after centering on circle.
Trial 2 -- Pencil held in the left hand, left eye closed.
Trial 3 -- Pencil held in the right hand, right eye closed.
Trial 4 -- Pencil held in the left hand, right eye closed.
Trials 5 to 8 -- Repeat trials 1 to 4 in order.

The above instructions were repeated prior to each of the eight trials. The recruits were asked continually if they had any questions, and the groups were observed carefully for indications of confusion or misunderstanding.

The following scoring procedure was adopted in order to make the scores on the eyedness test consistent with scores on the above test for handedness:

The eyedness score was the total number of left eye responses (the higher score representing more left eye responses).

The 9-point scale for eyedness (ranging from a minimum of 0 left eye responses to a maximum of 8 left eye responses) was transformed to a 5-point scale similar to that used for scoring handedness. [1]

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[1] The 9-point scale was transformed into a 5-point scale as follows: 1 = zero left eye responses, 2 = 1 or 2 left eye responses, 3 = 3, 4, or 5 left eye responses, 4 = 6 or 7 left eye responses, and 5 = 8 left eye responses.

A response was scored as left-eyed under any of the following conditions:

> If the pencil did not move when the right eye was closed.
> If the pencil moved to the left when the left eye was closed.
> If the pencil moved to the right when the left eye was closed.[2]

5.3.6 Laterality Test: Other Scores. In addition to the total score across the 16 items of the laterality test (15 handedness items and a single eyedness item), several other measures, derived from these 16 laterality test items, were also used as independent measures. The hand used in writing was scored as a separate item because of the wealth of previous research using this item as the only measure of laterality (reference 12). Inasmuch as earlier research (reference 12) has shown that measures of laterality can be submitted successfully to factor-analysis, the 16 items of the present laterality test were also factor-analyzed using a centroid solution to a varimax rotation of items. Each of the resulting factors was unit-scored using the 5-point

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[2] About 10% of the recruits in both groups consistently responded in this manner. This response, which is not described by Crovitz & Zener, indicates that the recruits had centered or focused on the circle with the left eye when both eyes were open, and then moved the hand to the right while closing, or after closing, the left eye in order to keep the pencil centered on the circle. Although this type of response indicates that these recruits misunderstood the instructions (or that the instructions should have been reworded to avoid this confusion), this response appears to be valid for indicating which eye was used to focus on the circle prior to closing the left eye.

scale previously described for single laterality items. Each of these factors was treated as an independent measure, with the score for each factor representing the frequency with which the left hand (or eye) was used for the total items included in that factor. Lateral consistency (use of the same side across a variety of tasks) was also used as an independent measure. Lateral consistency was determined for each recruit by first calculating the average item score for each laterality factor in order to correct for the different number of items in the various factors. The standard deviation about the grand mean of these average scores was used as the measure of lateral consistency. Equations for small samples were used in making these calcualtions.

The above factors were also scored for ambilaterality because this measure has been found to be associated with a variety of performances including reading achievement (reference 12). The following 3-point scale was used in scoring the items within each factor for ambilaterality: A 1 was for items having a raw score of 1 (right always) or 5 (left always); a 2 was for items having a raw score of 2 (right most of the time, but not always) or 4 (left most of the time, but not always); a 3 was for items having a raw score of 3 (left and right used with equal frequency). The total ambilaterality score for each factor was used as an independent measure, as was the total ambilaterality score for the 16 items combined.

Mixed eye-hand laterality has also been mentioned as a possible condition associated with reading performance (reference 13). This condition was determined in the present results by calculating the average score across the 15 handedness items and subtracting the eyedness score from this average. Both the relative and absolute differences between handedness and eyedness were used as independent measures. The relative scores ranged from a minimum score of -4 (indicating that the average handedness score was 1 and the eyedness score was 5) to a maximum score of 4 (indicating that the average handedness score was 5 and the eyedness score was 1). Zero was the midpoint, and this score indicated that the scores for handedness and eyedness were equal. In scoring for absolute differences, the direction (sign) of the differences was disregarded. Absolute scores ranged from a minimum score of 0 (both the eyedness and handedness scores were equal) to a maximum score of 4 (either the eyedness score was 1 and the average handedness score was 5, or the eyedness score was 5 and the average handedness score was 1).

The following summary presents the laterality scores used as independent measures in this analysis:

(a) Writing Hand -- the hand used for writing (5-point scale: 1 = right, 5 = left).

(b) Factor Laterality Total -- The total leftness score for each of the laterality factors.

(c) Handedness Total -- the total leftness scores for the 15 handedness items only.

(d) Grand Laterality Total -- the total leftness score for the combined (16) laterality items (15 handedness and single eyedness items).

(e) Laterality Consistency -- the standard deviation of the average scores for the laterality factors about the grand mean of these average scores.

(f) Factor Ambilaterality Total -- the total ambilaterality score for each of the laterality factors.

(g) Grand Ambilaterality Total -- the total ambilaterality score for the combined laterality factors.

(h) Mixed E-H (eyed-hand) Absolute -- the absolute difference between the average score for the 15 handedness items and the score for eyedness.

(i) Mixed E-H Relative -- the relative difference between the average score for the 15 handedness items and the score for eyedness.

5.4 Criterion Measures. The two major criteria were (a) the group (RR or C) to which the recruits belonged, and (b) reading achievement scores attained by the 34 members of the RR group. Reading achievement consisted of the difference between comprehension scores earned by the RR group on the Gates-MacGinitie Reading Test (Survey D, forms 1 and 2) before and after reading remediation. Forms 1 and 2 were administered in a counterbalanced order during pre- and post-testing. The reading comprehension scores represent grade levels (in tenths) which have been established from norms developed from nationwide samples of children attending public schools in the United States (reference 15). Norms are not available for adult or other discrete groups.

The Gates-MacGinitie has been found to have moderate to high reliability, and is correlated significantly with measures of verbal intelligence (reference 15).

5.5 Statistical Procedures. The independent measures were correlated with the criteria using Pearson product-moment correlations. Those independent measures found to be correlated significantly with the criteria were entered into a step-wise multiple regression analysis in order to determine which of these measures contributed uniquely to the criterion variance. Levels of significance are $p \leq .05$ (two-tailed).

6.0 RESULTS. The following sections present the findings for the above tests and measures.

6.1 Factor-Analysis of the Laterality Test. Factor-analysis of responses to the 16 laterality items resulted in 7 factors (6 handedness factors and a single eyedness factor) which accounted for 93% of the total response variance. The 6 handedness factors were labeled as follows: Swinging Movements (Factor 1), Drinking Movements (Factor 2), Fine Coordinated Movements (Factor 3), Gross Coordinated Movements (Factor 4), Cutting Movements (Factor 5), and Peeling Movements (Factor 6). Factor 7 consisted of the frequency with which the left eye was used for focusing the pencil on the circle, and was labeled "Eyedness." The loadings of the items in these factors, as well as the total response variance accounted for by each factor, are presented in Table 1. Following factor-analysis, the separate factors

were unit-scored for each recruit using the 5-point scale previously described. Scoring for items 2, 4, 6, 10, and 13 was reversed so that responses to these items would be consistent with responses to the remaining 11 items. These reversed items originally emphasized using the hands in a passive mode (such as holding a nail or a bottle). Reversal of these items placed emphasis on the active mode (such as the hand used to hit the nail or remove the bottle cap). The higher the original right hand response (the more often the right hand was used to hold a nail or bottle), then the higher the reversed (left hand) score (the more often the left hand was used to hit the nail or remove the bottle cap).

6.2 Correlations with the Group Criterion. The means and standard deviations of the 31 independent measures for each criterion group (RR or C) are listed in Table 2. For correlation purposes, the C group was assigned a score of 1 and the RR group was assigned a score of 2. Nine of the 31 independent measures were found to correlate significantly with the group criterion. These correlations indicate that those recruits who had higher GCT, MECH, ARI, CLER, and RPM scores, as well as those recruits who had more education, who were Caucasian, who had not modified hand use, and who scored high on the lateral consistency measure, were most likely to be members of the C group. The intercorrelation matrix of these nine measures with the criterion is presented in Table 3. The subsequent step-wise multiple

regression analysis using these nine measures resulted in a multiple R of .843 ($p < .001$). GCT scores were found to enter the multiple regression initially by accounting for 67.24% of the criterion variance. RPM scores entered next, accounting for an additional 2.32% of the criterion variance ($F = 6.387$; $p < .05$). Race was the last measure to contribute independently to the criterion variance, accounting for 1.51% ($F = 4.329$; $p < .05$). Table 3 also presents the beta weights for the three measures which entered significantly into the multiple regression.

6.3 Correlations with Reading Achievement. For the 34 members of the RR group, the average Gates-MacGinitie comprehension score prior to remediation was 4.653 (sd = 0.755), while the mean comprehension score following completion of the remedial reading program was 5.902 (sd = 1.331). The mean difference between pre- and post-test comprehension scores was 1.250 (sd = 1.113).

The results presented in Table 4 show that the total score for laterality Factor 5 (Cutting Movements), as well as the total ambilaterality score for Factor 5, were correlated significantly with the post-test comprehension scores. Those members of the RR group who used the left hand more frequently for cutting movements, or who were more ambidextrous in making these movements, attained higher post-test comprehension scores. The multiple regression resulting from these two laterality factors, however, did not

account for significantly more criterion variance than either of these factors alone. Reading achievement as measured by the difference between pre- and post-test comprehension scores was found to be related significantly to race and the total score on laterality Factor 2 (Drinking Movements). These findings (see Table 4) indicate that differences between pre- and post-test comprehension scores were larger for (a) non-Caucasians than for Caucasians, and (b) those recruits who used the left hand more frequently in performing drinking movements than recruits who used the right hand more often for these movements. The multiple R of .470 ($df = 31$; $p < .02$) which resulted from these two factors significantly improved on the total criterion variance accounted for by either factor alone.

Other significant findings presented in Table 4, but which are not related directly to post-training achievement, show that pre-test comprehension scores were associated positively with GCT scores and negatively with total scores on laterality Factor 6 (Peeling Movements). Those members of the RR group who entered the remedial reading program with higher verbal intelligence scores as measured by the GCT, as well as those who used the right hand more often in making peeling movements, had higher initial comprehension scores than those who had lower GCT scores and who used the left hand more frequently for peeling movements. The

multiple correlation of these two factors ($R = .614$; $df = 31$; $p < .001$) indicates that both factors made highly independent contributions in accounting for the criterion variance.

7.0 DISCUSSION. The above findings are interpreted in the following manner.

7.1 Differences Between Groups: Verbal Measures. The results are consistent with previous research which has shown that tests of intelligence and aptitude which are highly verbal are associated significantly with criteria of reading performance (references 4 and 5). The GCT, MECH, and ARI tests, which are heavily dependent on standard American English comprehension, vocabulary, and reading speed, were the measures that most effectively differentiated between Navy recruits in the comparison group and those who were enrolled in the remedial reading program. GCT scores were found to be the most highly significant and independent measure associated with the group criterion, subsuming the variance accounted for by every other measure except RPM scores and race.

The RPM, which was independently associated with the group criterion, also appears to be highly related to some form of verbal skill development, as demonstrated by the significant interrelationship found between the RPM and GCT, MECH, and ARI scores. Although earlier research has assumed that the RPM is a test of "observation and clear thinking" (reference 16) and is "independent of acquired knowledge or

'previously developed verbal skills" (reference 9), these assumptions are not entirely supported by the above results. The present findings provide evidence that the symbolic or verbal skills involved in successful GCT, MECH, and ARI performance are related directly to understanding the graphic or spatial relationships that are represented in the RPM. The perceptual (verbal-spatial) transformations required by the RPM may, however, be a unique feature of this test which added to GCT scores and race in differentiating between the criterion groups. The possibility exists that the different RPM response format used in obtaining the present results, as well as the bimodal distribution of scores, may have confounded these results, especially the association between the RPM and BTB scores. The present results should therefore be replicated on more normally distributed samples under conventional RPM test conditions in order to judge the validity of the present findings.

6.2 Differences Between Groups: Nonverbal Measures. Measures which did not emphasize verbal skill development to the same extent as the GCT, MECH, ARI, and RPM tests were found to be correlated less significantly with the group criterion, a result which also replicates previous findings (references 4 and 17). These tests include the CLER test, modification of hand use, lateral consistency, and education. Although education is assumed generally to be a measure of

intellectual and scholastic achievement -- characteristics associated directly with verbal skill development -- earlier research (references 18 and 19) has indicated that among Navy personnel, education also may be measuring conformity to conventional social standards and norms. The possibility exists, therefore, that poor social adjustment may be involved at least partially in the reading deficiencies of some members of the RR group. Poor social adjustment may deprive these recruits of the verbal (spoken or written) interactions that may be necessary for normal reading development.

The CLER test, which appears to be the only BTB measure with a large nonverbal component, was also found to correlate significantly with the group criterion. Inasmuch as the CLER test emphasizes the speed with which respondents can perceptually match or sort objects, this test may be measuring the effectiveness of visual scan, or perhaps some form of eye-hand coordination. Visual scan has been shown to be an important skill in reading development (reference 20). Another possibility is that the CLER test is measuring a perceptual factor similar to that which the RPM is assumed to measure. Previous research (references 21 and 22) has shown that such a factor may be associated with reading performance. This factor may improve reading comprehension by facilitating the transformation and decoding of sequential,

verbal information into unified, pictorial representations or perceptions (and vice versa).

Two measures of laterality were also found to be associated with the group criterion. These measures were lateral consistency and modification of hand use for writing or non-writing activities. These results indicate that the absence of lateral dominance (or perhaps competitive lateral dominance) may be related to poor reading skill development, a conclusion that conforms to data found for other types of performance (references 12 and 23). As postulated in this earlier research (reference 23), weak or competitive laterality may interfere with encoding and decoding of verbal (written) information at peripheral (sensory) or central (brain) levels. Peripheral effects may include poor visual scan patterns or slow and faulty subvocalizations, both of which may impair word attack skills. Central effects may involve poor verbal processing by one or both hemispheres of the brain. Previous findings (references 24 and 25) have demonstrated that poor readers are significantly worse than better readers at correctly identifying words presented to the left hemisphere of the brain. A test of these interpretations must, however, await validation of the present results (including validation of the laterality factors) on a larger sample of recruits. In addition, the present results show that these measures of laterality, as well as scores for ARI, MECH, CLER, and education do not contri-

bute more than GCT, RPM, and race in accounting for the criterion variance, and that perhaps future research should modify these measures or use a new set of measures in differentiating between reader groups.

7.3 Correlations of Race with the Group and Achievement Criteria. Race was also found to be associated significantly and independently with the group criterion, a finding which replicates previous observations (reference 21). The present results also show that non-Caucasian recruits scored lower than Caucasian recruits on tests of verbal intelligence and aptitude such as the GCT, ARI, MECH, and RPM. Other results, however, were found which confirmed earlier findings (references 6, 7, and 26) that race may moderate the validity of these verbal intelligence and aptitude measures. Although non-Caucasian recruits were found to score lower than Caucasian recruits on these verbal tests, and were more likely to be identified for reading remediation independent of these verbal test scores, they nonetheless were found to improve the most during the remedial reading program. These results indicate that if non-Caucasian recruits score poorly on verbal tests of intelligence and aptitude because of cultural differences, then they may progress more rapidly in the remedial reading program than Caucasian recruits because they (the non-Caucasian recruits) may have already learned many basic reading skills (visual

scan and word attack skills), and may require mostly additional vocabulary development.[3] Caucasian recruits, who have supposedly had a cultural advantage in vocabulary development, may progress more slowly than non-Caucasian recruits because of deficiencies in more basic reading skills. These results and interpretations are highly tenuous, however, because of the small number of non-Caucasians found in the present samples (none in the C group and twelve in the RR group), and because other factors (such as testing skills) may also be involved in these differences. The present findings do indicate, however, that the association between cultural-developmental factors and reading performance should be explored more extensively, and that present reading remediation programs should be prepared to adapt training to these cultural-developmental differences.

7.4 Other Measures Associated with Reading Achievement. The data for members of the RR group also show that laterality was a significant factor in remedial reading performance. Those RR recruits who more frequently used the left

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[3] Vocabulary development, however, is not trained extensively in the present Navy reading remediation programs. If this objective were emphasized more for some of the recruits, especially non-Caucasians, then post-test performance may have improved substantially more than was shown by the present results.

hand or were ambidextrous for specific movements (cutting and drinking) had higher post-test scores or improved more between pre- and post-testing than those recruits who more often used the right hand and were less ambidextrous. As previously mentioned, these results are highly tenuous because of the small sample size, the low significance levels, and because this number of significant correlations is near the frequency that would be expected by chance. At best, the present findings indicate that although measures of laterality may not be especially useful in differentiating between remedial and non-remedial groups, these measures may be worth collecting in future research on reading achievement among those who are enrolled in adult remediation programs.

Before these data can be used to predict reading performance, the present laterality factors should be validated on larger and more representative samples. Data on the frequency with which tasks described in the laterality questionnaire are performed (regardless of which hand is used), as well as some objective measure of the proficiency with which these tasks are performed, may also be useful in constructing a more valid laterality measure. Inasmuch as the above interpretations indicate that effects at the sensory or central levels may be involved in reading skill development, then measures of scan pattern, subvocalization, eye-hand coordination, or the speed and accuracy of trans-

posing and organizing verbal information into visuospatial perceptions may be useful in predicting reading performance. If these measures were found to be associated reliably with reading performance, then perhaps training which emphasizes the skills associated with these measures could be included in present adult remediation programs in order to improve the current level of reading achievement.

8.0 CONCLUSIONS. The following conclusions are derived from the above results and interpretations.

8.1 Verbal measures, especially the GCT, were highly useful in differentiating between remedial and non-remedial recruits. Perceptual measures such as the RPM also appeared to differentiate significantly and independently between these groups, although to a lesser extent than more verbal measures.

8.2 Nonverbal measures, including demographic information such as age, education, and modification of hand use, did not appear to be as useful as verbal and perceptual measures in differentiating between remediation/non-remediation groups. Although measures such as handedness, eyedness, and modification of hand use have interesting theoretical implications, these measures did not appear to be independently associated with the remediation/non-remediation criterion, and, therefore, appear to be of little practical importance.

8.3 Evidence exists that the CLER test of the BTB may be more a measure of nonverbal skills than of verbal skills.

8.4 The Raven Progressive Matrices (RPM) appears to require verbal fluency in order to be performed well, even though the RPM does not contain words and previous research has assumed that this test is free of verbal bias. The independent contribution made by the RPM in differentiating between the criterion groups, however, indicates that the perceptual (verbal-spatial) transformations required by the RPM may be important measures of reading skill development.

8.5 Race is a significant and independent factor in determining who requires reading remediation, as well as who will do best in a remedial reading program. Non-Caucasians are more likely to be found in remedial reading programs, but they also achieve larger gains in these programs than Caucasian recruits. These results indicate that the reading problems of Caucasian and non-Caucasian recruits may be different, and that perhaps the remedial reading programs should be restructured to diagnose and correct for these differences.

8.6 Measures of handedness and eyedness also appear to offer some promise in determining who will achieve the highest performance scores within a remedial reading program. These measures may be indicative of recruits who are having problems encoding and decoding words at the peripheral (sensory) and central (brain) levels. These problems may include poor visual scan patterns, inadequate or inappro-

priate subvocalizations, and impaired word processing by one or both hemispheres of the brain.

9.0 RECOMMENDATIONS. The following recommendations are made from the above conclusions.

9.1 Conventional verbal and perceptual measures should be used to identify and select Navy personnel who have reading problems and who should receive remedial training. These testing procedures should emphasize use of the BTB because these test data appear to be highly valid and readily available.

9.2 Special attention should be provided to the reading problems of minority groups. Minorities appear to have a much higher incidence of reading impairment than Caucasian recruits, and the types of reading problems found among minority groups may differ from the types of reading problems present among Caucasians.

9.3 Although the procedures and techniques for identifying poor readers probably do not require much additional development and evaluation, more basic research and development should be provided for determining factors related to reading performance and achievement among those who are enrolled in remedial training programs. Measures of handedness, eyedness, visual scan, subvocalization, and spatial perception may be especially useful. The information provided by this research and development could do much to improve the effectiveness of current remedial reading programs by adapting

this training to the many different psychological and physiological impairments which are most likely present among entering recruits.

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TABLE 1

Summary Statistics for Factor-Analysis of 16-item Laterality Test

Factor	Factor Label	Percent of Response Variance	Item No.	Item Identity	Factor Loading of Item
1	Swinging Movements	17.1	3	Which hand used to throw a ball.	.744
			14	Which hand used to hold a tennis racket or a ping pong paddle.	.736
2	Drinking Movements	13.7	7	Which hand used to hold a pitcher.	-.488
			11	Which hand used to hold a glass.	-.667
3	Fine Coordinated Movements	23.1	1	Which hand used in writing.	.786
			2	Which hand used to hold a nail.	-.394*
			5	Which hand used in drawing.	.789
			13	Which hand used to hold a shoe when polishing.	-.403*
			15	Which hand used to hold a fork.	.492
4	Gross Coordinated Movements	14.8	4	Which hand used to hold a bottle when opening the cap.	.575*
			10	Which hand used to hold a needle when threading it.	.504*
			12	Which hand used to hold a toothbrush when brushing teeth.	-.498
5	Cutting Movements	10.5	8	Which hand used to hold scissors when cutting.	.555
			9	Which hand used to hold a knife for slicing.	.649
6	Peeling Movements	9.7	6	Which hand used to hold a potato when peeling.	-.580*
7	Eyedness	4.1	16	No. of left eye responses used when focusing pencil on circle.	.480

*Scoring for these items was reversed from the original response (1 became 5, 2 became 4, 3 remained 3, and so forth).

TABLE 2

Summary Statistics for the 31 Independent Measures for the Experimental (RR) and Comparison (C) Groups

Independent Measure	RR Group (N=34) $\bar{X}$	SD	C Group (N=53) $\bar{X}$	SD
Age (years)	18.44	1.26	18.26	1.25
Education (years)	11.26	1.07	11.81	1.17
Race (% non-Caucasian)	35.29		0.00	
English was a Second Language (%)	5.88		3.77	
Modified Hand Use (%)	38.23		11.32	
GCT Score	34.38	6.49	53.62	6.58
MECH Score	42.32	6.98	50.91	7.29
ARI Score	39.24	6.77	50.35	5.89
CLER Score	48.24	10.48	53.02	8.70
RPM Score	20.59	6.91	31.43	3.83
Writing Hand	1.71	1.40	1.80	1.06
Factor 1 Total	2.85	1.96	2.79	1.91
Factor 2 Total	3.74	1.93	3.75	1.67
Factor 3 Total	8.24	4.87	7.62	4.02
Factor 4 Total	5.26	2.79	5.68	2.97
Factor 5 Total	2.53	1.09	3.08	2.03
Factor 6 Total	1.74	1.38	1.60	1.23
Factor 7 Total	2.38	1.35	2.47	1.40
Handedness Total	24.35	9.11	24.53	11.70
Grand Total	26.74	8.92	27.00	12.04
Lateral Consistency	0.89	0.42	0.71	0.36
Factor 1 Ambilaterality Total	2.38	0.80	2.34	0.73
Factor 2 Ambilaterality Total	3.03	1.29	3.53	1.31
Factor 3 Ambilaterality Total	6.00	1.61	5.85	1.20
Factor 4 Ambilaterality Total	3.91	1.40	4.36	1.52
Factor 5 Ambilaterality Total	2.35	0.72	2.43	0.84
Factor 6 Ambilaterality Total	1.21	0.53	1.19	0.44
Factor 7 Ambilaterality Total	1.74	0.78	1.79	0.88
Grand Ambilaterality Total	20.62	4.52	21.57	4.51
Mixed E-H Absolute	1.42	1.05	1.32	1.05
Mixed E-H Relative	-0.76	1.60	-0.84	1.46

TABLE 3

Intercorrelations, Beta Coefficients, and Multiple Regression of the 9 Measures Correlating Significantly with the Group Criterion

Measure	1	2	3	4	5	6	7	8	9	Group Criterion
1. GCT Score		.69**	.73**	.74**	.26*	.30**	-.26*	-.17	-.48**	-.82**
2. MECH Score			.45**	.62**	.18	.29**	-.17	-.19	-.42**	-.50**
3. ARI Score				.63**	.22*	.14	-.22*	-.22*	-.39**	-.67**
4. RPM Score					.29**	.26*	-.38**	-.07	-.35**	-.71**
5. CLER Score						.24*	-.10	.06	-.17	-.24*
6. Education							-.03	.21*	.27**	-.23*
7. Modified Hand Use								.18	.03	.32**
8. Lateral Consistency									.15	.22*
9. Race										.50**

Multiple R with the Group Criterion	
Measure	Beta Coefficient
GCT	-.56
RPM	-.25
Race	.25
R=.843; p ≤.001	

Note: N=87
*p ≤.05
**p ≤.01

TABLE 4

Intercorrelations, Beta Coefficients, and Multiple Regressions of Measures Correlating Significantly with each of the Three Reading Achievement Criteria

Measure	1	2	Pre-Test Reading Criterion
1. GCT Score		-.14	.50***
2. Factor 6 (Peeling Movements)			-.43**
Beta Coefficients	.45	-.36	R=.61***

Measure	1	2	Post-Test Reading Criterion
1. Factor 5 (Cutting Movements)		.73**	.35*
2. Factor 5 Ambilaterality Total			.37*
Beta Coefficients	.18	.24	R=.39*

Measure	1	2	Difference (Pre/Post-Test) Criterion
1. Race		.07	.34*
2. Factor 2 (Drinking Movements)			.34*
Beta Coefficients	.32	.32	R=.48**

Note: N=34
*p ≤ .05
**p ≤ .02
***p ≤ .01

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Several verbal and nonverbal tests and measures, including the General Classification Test (GCT), Mechanical Test (MECH), Arithmetic Test (ARI), Clerical Test (CLER), Raven Progressive Matrices (RPM), age, education level, race, speaking English as a native or second language, modification of hand use, and measures of handedness and eyedness were used to differentiate between a group of recruits enrolled in a Navy remedial reading

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program (RR group) and a non-remedial comparison recruit group (C group). These tests and measures were also associated with reading achievement attained by the remedial recruits as measured by pre- and post-test performance on the comprehension subtest of the Gates-MacGinitie Reading Test. The results show that verbal tests (GCT, MECH, and ARI) were correlated highly with the group (remedial/non-remedial) criterion. The data indicate that the RPM, which was associated significantly with the group criteria, was also highly related to these other verbal measures, although previous research has assumed that the RPM is a test of nonverbal spatial skills. The CLER test, however, was found to have only a low order correlation with these other verbal tests, indicating that the CLER test may be more a measure of nonverbal than of verbal skills. CLER scores were found to be correlated significantly with the group criterion. Other nonverbal measures, including education, race, modification of hand use, and consistency of hand and eye use, were also shown to differentiate significantly between the two groups. Multiple regression analysis demonstrated that the GCT, RPM, and race subsumed the criterion variance accounted for by the other significant measures, with those recruits who had lower GCT and RPM scores, and who were non-Caucasian, being more likely to be in the RR group. Achievement within the remedial reading program, however, was found to be positively and significantly related to race and to several specific types of handedness. Non-Caucasians, as well as those who used the left hand to perform peeling and drinking movements, were more likely to attain higher post-test reading comprehension scores and show larger improvements over pre-test reading comprehension scores than Caucasian recruits or recruits who used the right hand to perform these hand movements. These results show that conventional tests of verbal intelligence, especially the GCT, perceptual measures such as the RPM, and cultural or socioeconomic factors such as race, are useful in differentiating between poor and better readers. Determination of whether a recruit should be in the remedial or non-remedial group was easier, however, than determining reading comprehension achievement among members of the remedial reading group. Race and handedness were found to be among the most useful measures in determining reading achievement among members of the remedial reading group. The findings for handedness may be an indication of the facility with which word processing is accomplished by poor readers at the peripheral (sensory) and central (brain) levels, while the results for race may indicate that while non-Caucasian recruits are more likely than Caucasian recruits to require reading remediation, non-Caucasians perform better in the remedial reading program than Caucasian recruits. Non-Caucasian recruits may, therefore, have reading problems that are related to cultural factors such as inappropriate vocabulary development, while Caucasian recruits may have more basic and difficult reading problems such as poor word attack skills or impaired visual scanning patterns. If this interpretation is correct, then current remedial reading programs should be restructured to correct for these entrance level differences.